



## Editorial

## Science in the UK – whereto now?



Humour in Britain is appreciated for its quirkiness and ironic self-deprecation and can sometimes seem baffling to the outside world. The outcome of the recent United Kingdom referendum where a narrow-ish majority voted to leave the European Union is certainly perplexing to most onlookers and, if its consequences were not so far-reaching, might be laughed off as an illustration of such absurd humour. One of the most farcical aspects of the vote is that no one has any idea what “Brexit” actually means no matter how often the ignorant slogan “Brexit means Brexit” is repeated. However, an immediate consequence is that the uncertainties created by the vote, and its potential impact on science, continues to be the subject of widespread, anxious and incredulous debate amongst scientists in the UK and between their many friends and collaborators in the world-wide scientific community. Objectively, it is difficult to discern a single coherent argument that can be made for Brexit, and there can be little doubt that the human, societal and financial implications of this needless debacle could be both wide reaching and damaging.

UK science is highly competitive and EU and UK researchers have become linked in an extensive collaborative network that has been of immense benefit to UK (and EU) science, with levels of inter-country collaborations within the EU (13%) similar to those of inter-state collaborations within the USA (16%) [1]. Together with scientists from other EU countries, British scientists comprise around 22% of researchers worldwide, way ahead of the USA (17%) [2]. European researchers are also productive as measured by publications and author around 34% of the world’s research outputs, with the USA trailing at 23% [1]. Between 2005 and 2014, UK researcher output rose from 70,201 to 87,948, second only to Germany (73,573–91,631) and way ahead of next-placed France (52,476–65,086). Indeed, for publications in biological and medical sciences, British authors are the most prolific by far (Fig. 1). UK institutions have been awarded by far the most research grants by the European Research Council [3], which funds individual projects solely on the basis of their scientific excellence and so helps researchers bypass what is sometimes perceived as a less objective distribution of monies from national research councils. Between 2007 and 2015, the UK accounted for 639/3056 grants, with next-placed Germany obtaining 440. The UK has been similarly successful with the EU’s Horizon 2020 programme, with nearly 12% of the applications received under the first 100 calls accounting for 15% of the available funding [4]. The Royal Society reckons from data released by the UK Office of National Statistics that between 2007 and 2013 the UK received a net amount of €2.9 billion in direct

EU funding for research, development and innovation activities [5].

EU funding has become essential to British science, since it is augmenting UK-based research at a time when British government funding is decreasing. Undoubtedly there are many ways of presenting the available financial data, but a straightforward reading of the likely unbiased UNESCO Science report reveals that the ratio of UK gross domestic expenditure on research and development (GRED) to GDP declined from 1.75 in 2009–1.63 in 2013, at a time when the average ratio for all 28 EU countries rose from 1.94 to 2.02 [1]. The UK government’s own figures show that whilst in 2014 it spent £11.0 billion on science, engineering and technology, a nominal increase of 0.4% compared with 2013, once inflation is taken into account this represented a 1.0% decrease. Furthermore, the contribution of the UK Research Councils, which amounted to 31% of all expenditure in this area, decreased by 3% in current prices compared with 2013 [6].

The financial argument for the UK remaining within the EU is clearly overwhelming, but is but one aspect of the importance of membership of the EU for British and European science. The continued free movement of people is similarly significant and is vital for creating global network of contacts, helps stimulate innovation and the inherent exposure to different cultures and viewpoints helps make this a better world. The English-speaking UK with its close links to the USA is a very attractive destination for experienced academics, students and post-doctoral workers alike, who contribute not just their talents and enrich society with their cultural diversity but also make a significant economic and financial contribution to the UK in general and universities in particular. It is particularly ironical (more British humour?) that the UK government sees tougher regulation on universities as an appropriate way of reducing net immigration and argues that universities should develop sustainable funding models that are not so dependent on international students [7]. How ingenious then to threaten the potential for EU funding, which goes mainly to scientists working at universities and research institutions, by withdrawing from the EU. Furthermore, most students return to their home countries and carry back with them the impressions, values and principles they have acquired in the UK and become part of the international collaborative network that has become the hallmark of modern science. Of course, the British pharmaceutical and biotechnology industries and many small and medium enterprises innovating scientific instrumentation, medical devices and diagnostic kits also make an essential contribution to overall scientific output and advances and

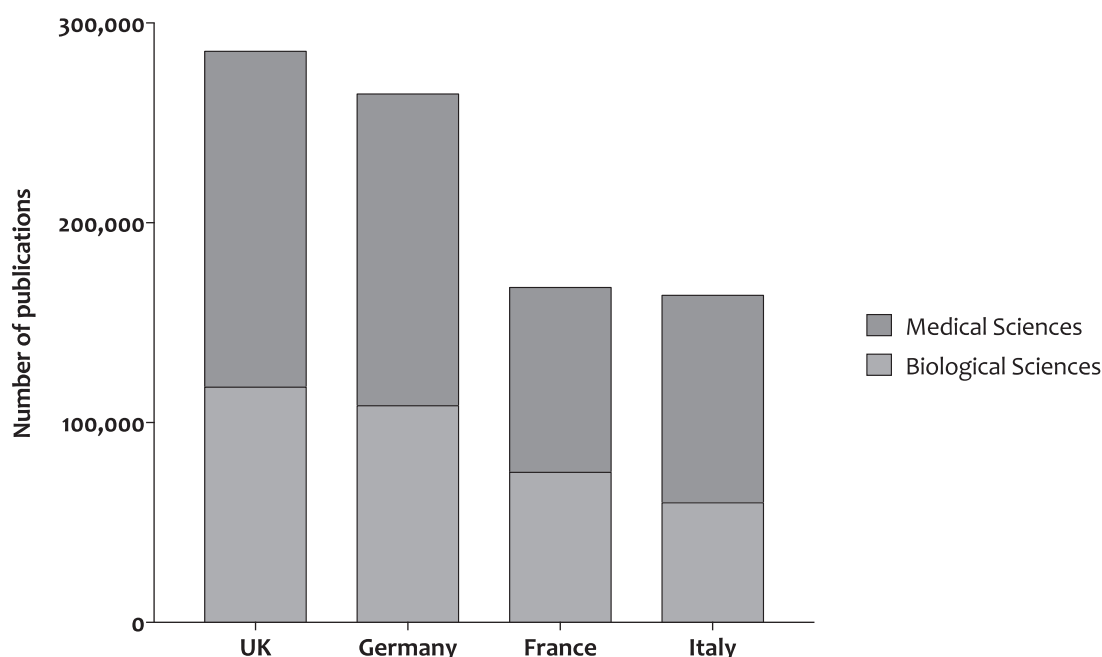


Fig. 1. Scientific publications authored by scientists located in the four largest EU member states.

benefit from trans-national funding and the free movement of people and services.

An authoritative and comprehensive examination of the European publics' attitude to science and technology suggest that most people understand the fundamental importance of these issues [8]. The increasing importance of collaborative research is acknowledged by 74% of respondents, with only 5% disagreeing. Interestingly the UK was second from bottom amongst all EU countries, although a healthy 64% agreed with that statement and only 9% disagreed. Most people also believe that collaborative research is in the national (66% vs 10%) and society's (69% vs 9%) interest and that it makes science more creative and efficient (62% vs 9%). Again it is notable that UK respondents are not as convinced (51% vs 14%). The public also understand that it is normal for EU researchers to move from one member state to another to further their career (59% agree, 11% disagree), but it is again noticeable that the UK public are less likely to agree with this requisite: only 46% agree, whereas 18% disagree). Finally, 72% of Europeans believe, compared to 7% that do not, that it is important to create European research centres that allow researchers from all EU countries to collaborate at one physical location. Again the UK response is somewhat less positive, with only 61% of that opinion, compared to 11% that disagree.

One of the most notable features of the referendum campaign in the UK was the reliably ill-informed and coarse standard of discourse, which gave rise to many dispiriting comments from both sides of the divide. The true consequences of leaving the EU were rarely made clear in a manner that could be objectively deliberated by the electorate; instead arguments were generally characterised by emotion, fabrication and misrepresentation of facts. For scientists, one of the most foolish assertions surely was the declaration by the then justice secretary Michael Gove, a graduate of the University of Oxford, that "people in this country have had enough of experts". Whilst this comment appeared to be directed specifically at economists, it nevertheless represents a shocking attitude by a supposedly educated member of the establishment. However, there is a wider context to consider, since the media regularly broadcasts scientific and medical discoveries, and scientists appear as experts to explain one finding or other, frequently offering different opinions. Hence comments such as the one by Mr Gove should

make us think and re-evaluate our own role as scientists and how the wider community perceives our role and expertise.

The usual definition of an expert is someone who is knowledgeable about or skilful in a particular area. An expert's role with regards to communication is to use that expertise to provide impartial, comprehensive and relevant research- and fact-based evidence. To be credible, the expert must convey sincerity and integrity and if the communication is done competently, sensitively and appropriately, that evidence should provide the information a target audience requires to act, or in the case of the UK referendum, vote rationally. Ultimately, an expert's value depends on whether the public can trust that expert's testimony. Trust is precious and must be earned, and there have been several reasons why some people might be mistrustful of scientists. One of the most egregious instances of how dubious science affects public wellbeing is provided by the controversy surrounding the link between the measles mumps and rubella vaccine and autism [9]. Despite numerous studies refuting any such link [10–14] and despite judgements by the US federal vaccine injury compensation court upheld on appeal [15], many members of the public remain unconvinced that there is no connection between the two [16–18]. Other examples include serious incidents biosafety incidents, which have occurred in laboratories operated by the Centers for Disease Control and Prevention (CDC) [19,20] and there are frequent reports of safety violations and accidents at research facilities around the world. In the UK a Guardian newspaper investigation uncovered over 100 accidents or near-misses at the high-security labs that handle the most dangerous viruses and bacteria [21]. Such events must be handled in a transparent, candid and respectful manner if they are not to damage people's trust in science and scientists.

In any event, the public's opinion of science and scientists is not straightforward. Any survey needs to be taken with a pinch of salt these days, but the 2010 European Commission's report on science and technology paints a broadly positive picture of the general publics' perception, albeit with a few worrying tendencies. There is a broad awareness of science, with 79% of Europeans either very or moderately interested in new scientific discoveries and 61% feeling either well or moderately well informed about them [8]. They are also optimistic about the effects of science and technology, with 75%

expecting science and technology to provide more opportunities for future generations, although 57% feel that scientists should put more effort into informing the public about these changes. Encouragingly, a majority (55%) of Europeans sees the need for a public dialogue when decisions about new developments in science and technology are made [22]). However, 62% feel that science and technology can sometimes damage people's moral sense and that 53% agree with the statement that, because of their knowledge, scientists "have a power that makes them dangerous". The jury remain out on how all of this affects the public's trust: 58% of Europeans think that the increasing dependence on funding from industry means that scientists can no longer be trusted to tell the truth about controversial scientific and technological issues. Interestingly, 70% of respondents in the scientific powerhouse Germany 70% agreed with that statement. Perhaps there is a link to the perception of 50% of respondents who believe that private funding of scientific and technological research limits the ability to understand things fully. Conversely, in the UK scientists are a trusted profession, with the two most recent Ipsos Mori veracity indices suggesting that 83% (2014) [23] or 79% (2015) [24] of the UK population trusts scientists to tell the truth.

So what are we to do? Most scientists (85%) see the public's lack of knowledge about science as a major problem and 76% also complain about the media's lack of distinction between sound science and unscientific twaddle [25]. I strongly believe that one of the lessons of the Brexit debacle is that scientists must become far more proactive in their involvement with and influence of politics. We must accept that we need to engage in an active role with the general public and demonstrate the significance and benefits of our research, perhaps by joining political parties and shaping policies right from the start. Historically, scientists believe in transparent, respectful and rational debate that tolerates and even encourages different opinions. We are used to developing hypotheses, searching for factual evidence and modifying our hypotheses if our experimental facts change, all in a search for truth. Few scientists, and certainly not those in academic posts, are motivated by avarice, many, especially in less democratic countries, continue to be examples of moral courage and most have a sincere social conscience, sense of solidarity and are colour-blind. If we really are entering a post-truth world that seems to be characterised by narcissism, material greed, lack of moral courage and unwillingness or inability to stand up for principles, I would argue that scientists should act as beacons for pluralism, social justice, tolerance and reflective thought. Of course, rational debate and facts may not be sufficient to convince an audience that has an emotional attachment to its views. Although scientists know that a questioning attitude is preferable to a dogmatic approach, most people are confused by scientific debate where several, sometimes contradictory, opinions are discussed and where there may be more than one correct answer. We need to acknowledge this; but we also need to inject some passion into our arguments, especially as there is plenty to be passionate about: investment in science is a positive thing and is essential for prosperity, it benefits society, provides employment, improves health, brings people and cultures together, is generally a force for good and, above all, science is exciting.

With regards to Brexit, for all its faults, the EU has nourished these values, especially with its drive towards funding excellence, encouraging the exchange of people and focussing on topics that individual nation states tended to neglect. This should be an incentive for us to "take back control" and not let politicians, journalists and other special interest groups destroy our precious network of friends, collaborators, institutions and openness we have built up over the past 40 years. There are many issues that must be tackled and we must not be afraid to discuss these openly and with the greatest possible transparency. These include the serious problems associated with inefficiency, lack of reproducibility

and mistaken research priorities of biomedical research [26–31], laboratory errors [32,33] and other issues highlighted in numerous publications [34–40]. We might also want to consider speaking up against the challenges associated with the politicians' love for ludicrous quality metrics, the publish-or-perish culture that fosters the publication of poor research, the associated inadequacy of the peer review system and the increasing focus on translation research at the cost of creative exploration. None of these issues can be addressed unless we are willing to engage with the many interests that have driven these developments, some of which are self-inflicted and self-perpetuating. But involve ourselves we must, otherwise we cannot complain if others make vital decisions against our judgements and interests that might jeopardise our futures.

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